5.0 Site Analysis

5.1 Overview

Transportation planners and analysts in local/municipal agencies are often interested in predicting the impacts of new facilities, commercial developments and other types of establishments on the volume and spatial distribution of freight traffic in their respective jurisdictions. The purpose of site analysis is to estimate, within an acceptable level of accuracy, the number of new commercial trips generated by a new or planned facility and determine whether or not the existing network of primary highways, local roads, municipal streets and other transportation facilities can sufficiently handle the projected traffic demands. Thus, in addition to number of new trips, the analyst is also concerned about which routes these new trips will take and at what time periods during the day. The generic term "facility" is used in this chapter to refer to any site location where some type of economic activity is carried out.

Site analysis is appropriate only for planned facilities that have significant impacts on freight traffic including strip malls, industrial factories or plants, major retail stores and special trip generators such as intermodal transfer facilities.

While site analysis can be applied to both existing and planned facilities, usually the procedures for analyzing existing sites involve simple traffic counts and observing where and when these counts are taken. This chapter focuses on the relatively more complicated analysis of planned sites, in which the following steps are involved:

1. Obtain relevant land use and economic activity data pertaining to the facility from the owner, developer, designer or constructor.

2. Identify the network of highways, roads, streets and other transportation facilities in the immediate vicinity of the site which will serve the traffic generated by the facility.

3. Predict the number of freight trips (by mode) that will be generated by the facility based upon the information gathered from Steps 1 and 2. These trips include those going into as well as those coming out of the site.

4. Determine the origins and destinations of the new trips. These include short-haul (i.e. nearby or adjacent) as well as long-haul (remote) origins and destinations.

5. Assign the trips to the adjacent highways and transportation facilities based upon the characteristics of the network and knowledge of trip origins and destinations.

6. Determine the changes in level of service of the transportation facilities as a result of the new trips.

This manual focuses on commercial vehicles. However, there are also changes in passenger vehicle demands that would result from the new facility. In estimating the changes in traffic volumes and levels of service on the transportation network, the total freight and passenger trips attributed to the site should be calculated.

The following sections describe in detail the steps involved in site analysis, including additional information on how data collection and trip generation estimation may be conducted for major intermodal terminals and special trip generators. An example of site analysis in Green Bay, Wisconsin is presented in Chapter 9, Section 9.3.

5.2 Data Gathering

Site analysis normally begins with data gathering in which all information pertaining to the proposed facility that is relevant to the analysis is assembled. This information can be obtained from various sources including the developer, designer, owner, contractor or the local/municipal/city engineer's office which issues construction permits and approves plans and specifications. Data gathering for site analysis includes but is not limited to the following:

- Company/Owner name and address;
- Type of facility to be operated in site (e.g. retail, industrial, manufacturing, warehousing, etc.) and the activities involved;
- Size of the facility in terms of land area, floor area, number of employees;
- Type of commodities, products or services produced and consumed;
- Anticipated volume of shipments and receipts expressed in either weight, volume, dollar value or other freight units;
- Type of vehicles or carriers to be used for transportation as well as the company or agency who will be responsible for shipping;
- Locations of markets for commodities and services produced (e.g. local, intercity, out-of-state, international, etc.);
- Locations of markets for materials, commodities or services used (e.g. local, intercity, out-of-state, international, etc.);
- Locations of intermediate facilities (i.e. warehouses, consolidation points, etc.) which will serve the new facility.

- Frequency and timing (schedule) of shipping operations.

While basic information such as owner/company name, size of facility and type of activity can be determined mostly from available documents, the more detailed data may only be obtained by conducting interviews or surveys with the appropriate individuals. These include questions relating to the type and volume of commodities used and produced, the locations of origins and destinations of the shipments, and the schedules.

An interview with the potential shippers and receivers may also be necessary to obtain some of the information listed above.

■ 5.3 Network Identification

All transportation facilities surrounding the site need to be identified prior to conducting freight traffic analysis. These facilities include all types of roads (i.e. primary, arterial, suburban streets, etc.), transportation terminals, railroad tracks, waterways and airports. The types of mode available for freight transport in the area around the site and their level-of-service characteristics have a substantial influence on the choices made by shippers and carriers for the planned facility (see Chapter 2 - Factors Affecting Freight Demand).

Maps of the general area showing streets, railroads and other transportation features in relation to the site not only help identify what options are available for freight transport but also help establish the relationships among these options. For example, the presence of a nearby railroad terminal may make it more attractive for the new facility to ship its products and commodities by rail instead of other alternative modes such as highway. In reality, other modal service attributes (e.g. cost), and site-specific characteristics such as those identified in Section 5.2 (Data Gathering), will influence this decision.

In identifying the network of transportation facilities, all their existing physical and operational characteristics have to be described including size, capacity, traffic volumes, geometry, speed limits and any other restrictions on use or access (e.g. truck size and weight limits). The characteristics of the traffic which the facilities serve may also be relevant to the analysis.

Sources of transportation network and traffic data include the Design and Traffic Divisions of City or Local Governments, Departments of Transportation, Metropolitan Planning Organizations and other planning agencies.

■ 5.4 Trip Generation

Predicting the number of freight trips (by mode) generated by a new facility uses much of the information described above. In Chapter 4, Section 4.2, we described a simple and direct procedure for estimating commercial vehicle (truck) trips using trip generation rates per employee and household. The rates for four different land use/employment categories were derived from Phoenix data and recommended for use in trip estimation.

However, unlike the aggregate planning problem presented in Chapter 4, detailed site analysis requires a more accurate estimate of the number of trips generated. These estimates should ideally be based on the comprehensive knowledge of the characteristics of the planned facility, including but not limited to the number of employees and households. More precise traffic projections can be inferred from such additional information as type, weight and volume of commodities produced and consumed, the sizes and capacities of vehicles, modes and carriers that are available, the frequency and scheduling of shipments, the storage and handling operations, and other factors that influence the total demand for freight transportation by the facility.

The volume of freight movement is closely associated with commodity classifications and land use. Volume is generally expressed in tons and ton-miles, or in truck load equivalents (TLE's). The specific cubic space occupied by a particular commodity may impact the number of truckloads required to move a given measure of that product. Manufacturing plants are destinations for raw materials or parts, and origins for finished goods or parts that will move elsewhere, perhaps across the county or across the country. A grocery store warehouse is likely to receive goods from near and far, but will then distribute them to local stores in a regular "daisy chain" type pattern.

The analyst should explore these and the many other types of relationships between anticipated freight traffic and the site/facility characteristics. For example, Appendix D contains tables of trip generation rates for various types of commercial vehicles in different locations. The tables also identify the specific land use/SIC code for which the rates can be used. In addition to the total number of employees, the total floor/building area or total land area of the facility can be used to predict the trips in case the number of employees is unknown or deemed inappropriate for trip prediction.

A combination of different land uses and other factors affecting freight demand can also be used to more accurately estimate freight trips by mode. Some regression equations, such as those included in Appendix D for truck trips, predict daily freight trips as a function of land use category, number of employees, building/floor area and total area.

In addition to the total number of new trips, the analyst may also be interested in the distribution of these trips on a given day, week, or even month. These temporal characteristics are important in determining the impacts of the new traffic on the peaking patterns around the site.

Using site-specific trip generation rates, regression equations or other methods can significantly improve the forecasts of the demands for freight transportation due to the new facility. Aside from the information on trip generation provided in Chapter 4 and Appendix D (which only pertain to trucks and commercial vehicles), the analyst can utilize a variety of local, statewide and national data sources or organizations which deal with the impacts of new facilities on freight traffic for different modes. Appendix F through M contain a listing of these sources.

In the case of special trip generators such as intermodal terminals, trip generation estimates can be obtained through direct contacts with a limited number of firms and with specific limited questions, in particular if the planning agency has been building contacts with the freight community over a period of time. Actual trip generation data can generally be obtained through direct contacts, observation, or surveys. If not, the default values found in Appendix D may be applied. The following describes types of data that may be sought for different modes.

Highway

Average daily truck activity per site, by truck classification- inbound and outbound. This may require a visual classification count, depending on the size and importance of the facility, however, in many cases the fleet manager of the planned facility will be able to provide accurate estimates.

Water

For ports, loadings and unloadings will likely be provided in twenty foot equivalent units (TEUs), or forty foot equivalent units (FEUs). Maritime data sources such as the *Port Facilities Inventory* provide extensive data on over 4,000 major river and ocean ports, including location, cargo handling capacity, and physical characteristics. Maritime data sources such as *U.S. Waterborne Exports and Outbound Intransit Shipments* and the converse for imports include shipping weight and value by port, and the percentage of containerized cargo. *Tonnage for Selected United States Ports* includes tons handled - total, domestic and foreign. (See Appendix K-4d).

Tonnage into or out of a port facility will require an additional analysis step to distinguish between rail and truck movements. One method is to calculate total tons, convert to truck load equivalents, identify total rail tons in or out of the port (see below), and subtract rail tons from port tons. Several commercial firms provide "value-added" services to databases such as the above, to decrease the need for user manipulation and increase the utility. (See Appendix K - 3b).

Rail

The primary rail data source related to trip generation is the *Carload Waybill Sample*. The public use version of the sample is aggregated to the BEA-to-BEA level. (There are 173 Bureau of Economic Analysis regions in the country). However, state agencies may access the confidential information, that contains extensive rail shipment data. Data include origin and destination points, number of cars, tons, length of haul, participating railroads and interchange locations. (See Appendix K-4c).

Air

The *Airport Activity Statistics of Certificated Route Air Carriers* publication presents detailed data on freight express and mail traffic carried for each airport and individual airline. *The Air and Expedited Motor Carriers Network Guide* and the *Express Carriers Association Service Directory*, both produced by the Film, Air and Package Carriers Conference, include operational information on AEMCC members by airport code. (See Appendix K-4a).

If actual trip generation data cannot be obtained through primary surveys or secondary data sources, the default values in Table 5.1 may be applied to either firm or employee data. Caution should be used, as the values are based on a single study of truck trip rates for air cargo operations at JFK International Airport.

Table 5.1 - Trip Generation Rates for Air Cargo Operations

Type of Firm	No. of Firms	Number of Workers per Firm	Truck/Van Trips per Day per Firm	Truck/Van Trips per Day per Employee
Courier	3	35	26	0.75
Forwarder	9	39	27	0.67
Broker	5	20	22	0.91
Trucking	1	20	25	0.50
Total/Average	18	33	25	0.73

Source: *Characteristics of Urban Freight Systems*, Table 57; original source *Transportation Issues Survey Summary,* furnished by New York Metropolitan Transportation Council.

Other Modes

The specialized database section (Appendix K-4) also includes data sources for pipelines, coal movements, military transportation, Mexican and Canadian trade, imports and exports, and other topics. State or regional planning agencies with even more specialized needs may refer to the *Directory of Transportation Data Sources*, *TruckSource*, or commercial sources.

5.5 Trip Distribution

The estimated freight trips generated by the planned facility may have origins and destinations at several different locations. Depending upon the characteristics of the facility and the types of products and shipments involved, the freight trips can range from very short-distance local trips to long-haul (interstate) and even international trips. Origins and destinations of trips have considerable influence on the modes used and routes taken.

The following classifications of origin-destination trips can be used in site analysis :

1. **Long haul -** Trips into or out of the site with origins or destinations more than 250 miles away from it. These trips usually carry many of the inputs used in both manufacturing and wholesale distribution operations. Long-haul trucks are usually large and compete with rail and water. These trips may also include linkages to ports (particularly container traffic).

2. **Short haul (interstate or interregional)** - Moving within about a 250-mile radius of the site. Example of these trips are delivery movements from a wholesale distribution warehouse to outlying retail establishments.

3. **Local trips** - Essentially short-distance local delivery operations. This type of traffic includes small shipments from wholesale distribution centers to retail stores or to local manufacturers. It also includes drayage, which is the short-range transfer of cargo to or from rail or port facilities to manufacturing or distribution facilities. Large trucks are frequently used for drayage.

The origins and destinations of trips that end in the planned facility may be established based upon the types of materials, raw products, goods and commodities that are used or produced by the facility. For example, a major auto dealer will most likely have freight trips that originate from auto assembly plants or factories. Similarly, a dairy plant will generate trips that include distribution to grocery and retail stores.

Knowledge of trip origins and destinations for the site allows the trips predicted in Section 5.4 to be assigned to various elements of the transportation network identified in Section 5.3.

5.6 Trip Assignment

Trip assignment relies essentially on all pieces of information derived and developed from data gathering, network identification, trip generation and trip distribution. Trip assignment is the penultimate step in site analysis -- one which involves the 'loading' of predicted freight trips, by mode and origin/destination, to the transportation facilities around the site. Again, the modes can include streets and highways, railroads, waterways, terminals and airports. Origins and destinations may be classified as local, intercity, intra-state, interstate or international.

The criteria that can be used to assign trips to the transportation network include capacity, cost, distance, travel time, traffic volumes, level-of-service (i.e. congestion), speed/weight/volume/height limits and other parameters. In some cases the choice of route taken is implicit in the choice of mode. For example, if some freight trips are to be made by barge and there is only one waterway within the vicinity of the site, the trips are automatically assigned to the existing waterway. On the other hand, for truck trips on streets and highways, there are usually a number of routing options and the trips need to be assigned based on the factors identified above.

As mentioned earlier, both the passenger and freight trips added onto the transportation network as a result of the planned facility have to be determined and used in calculating the impacts on traffic conditions and levels-of-service of the affected area.

■ 5.7 Level-of-Service Analysis

Depending upon the volume of traffic added and the existing capacity of the transport facilities, the level-of-service of roads, highways and other facilities in the area may be seriously impacted by the introduction of the new development. These impacts can be measured in terms of delay, congestion, accidents, physical and functional deterioration, air quality, noise and other level-of-service characteristics which are influenced not only by the volume of traffic but the presence of freight-related vehicles such as trucks.

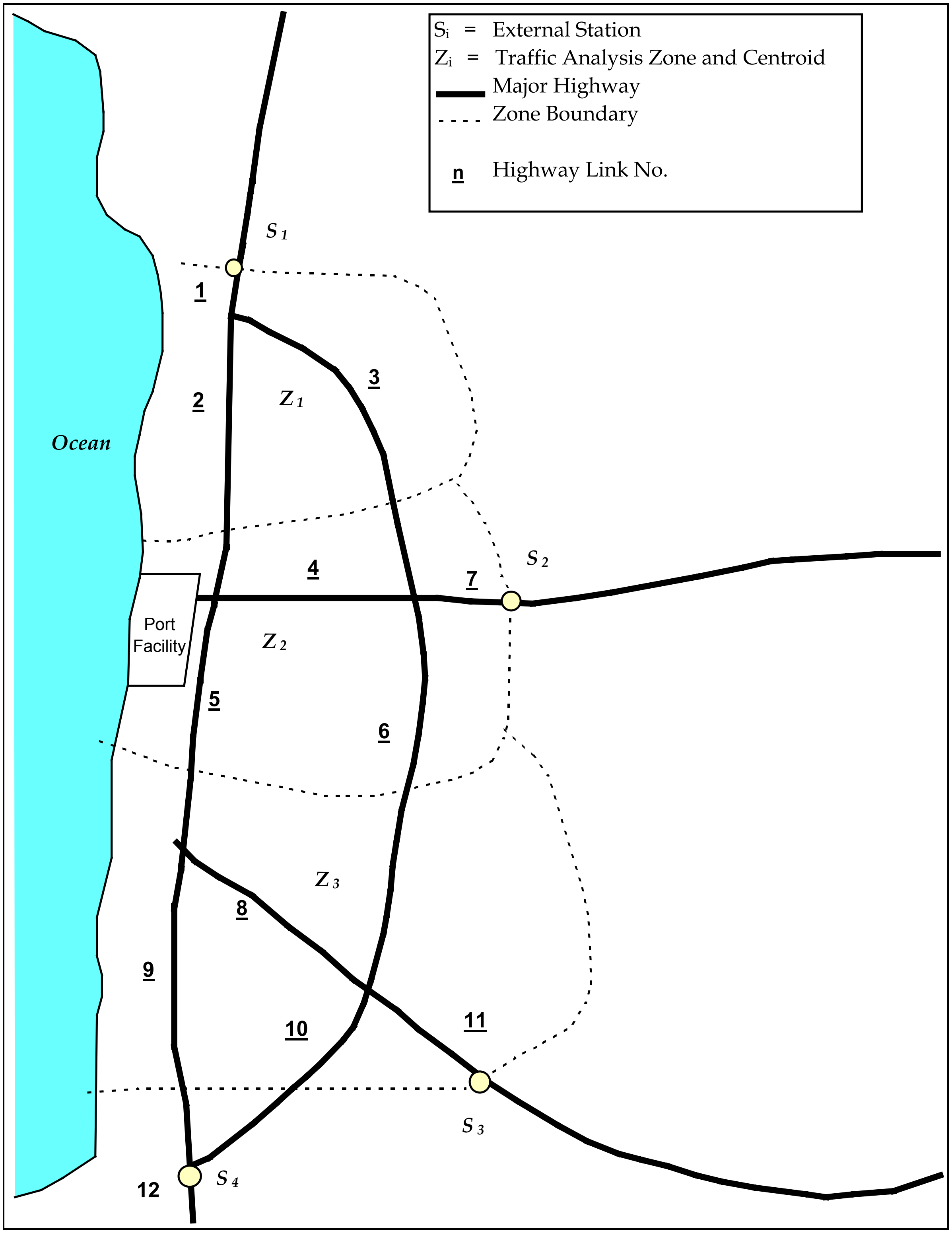
Since level-of-service characteristics are a function of time, it would be important to determine the impacts of the new freight trips on both the peak and off-peak traffic around the site.

The purpose of level-of-service analysis is not only to determine what the potential negative impacts of added freight traffic will be, but also to identify ways that can alleviate these problems or even prevent them from happening. In this way the analyst can make appropriate plans or recommendations.

■ 5.8 Illustrative Example

Suppose that a major port terminal is being planned for the hypothetical study area used as example in Chapter 4. Figure 5.1 shows the proposed location of this large facility in Zone 2 of the area. The planning agency wants to determine the impacts of the proposed facility on the traffic volumes and service levels on the major arteries in the area. For the purpose of the site impact analysis, the road segments have been numbered as shown in the figure.

Figure 5.1 Location of Planned Port Facility in the Hypothetical Study Area



The number of lanes, capacities, existing traffic volumes (commercial and non-commercial vehicles) and daily volume to capacity (V/C) ratios in each link are shown in the table below:

Existing Link Characteristics and Traffic Conditions

Highway Segment	No. of Lanes	Traffic Volume (pces/day)	Traffic Capacity (pces/day)	Volume/ Capacity
1	8	120,188	384,000	0.31
2	6	106,695	288,000	0.37
3	6	121,421	288,000	0.42
4	6	81,940	288,000	0.28
5	6	102,145	288,000	0.35
6	6	114,524	288,000	0.40
7	6	71,904	288,000	0.25
8	4	103,082	192,000	0.54
9	6	94,665	288,000	0.33
10	6	91,324	288,000	0.32
11	4	20,920	192,000	0.11
12	8	103,104	384,000	0.27

Three thousand (3,000) new employees are expected to

ee thousand (3,000) new employees are expected to work in the proposed port facility whose major operations include:

- Processing of export/import products
- Warehousing
- Containerization of commodities

The changes in non-commercial vehicle trips in various zones that can be attributed to the port facility are shown below:

Non-Commercial Vehicle Trips at Zones (vehicles/day)

Zone	No. of Trip Ends (w/o Facility)	No. of Trip Ends (w/ Facility)	Change
Zone 1	48,000	49,000	1,000

Zone 2	58,000	62,000	4,000
Zone 3	52,000	54,000	2,000

At each external station, it is estimated that the non-commercial vehicle trips will change due to the presence of the port facility as follows:

Non-Commercial Vehicle Trips at External Stations (vehicles/day)

External Station	No. of Trip Ends (w/o Facility)	No. of Trip Ends (w/Facility)	Change
Station 1	47,275	47,775	500
Station 2	22,277	22,677	400
Station 3	8,814	9,114	300
Station 4	40,572	41,072	500

The change in employment for Zone 2 and the resulting changes in commercial vehicle trips (using Trip Generation rates from Table 4.1 for Manufacturing, Transportation etc.) for each vehicle type are shown below:

New Commercial Vehicle Trip Origins/Destinations for Zone 2

	Without Facility	With Facility	Change
Employment	9,362	12,362	3,000
Trip Origins/ Destination	(Using Trip Generation Rates from Table 4.1 for Manufacturing, Transportation, Utilities, etc.)		
• Four-Tire	8,782	11,596	2,814
• Single Unit	2,266	2,992	726
• Combination	974	1,286	312

The resulting total commercial vehicle trips for each vehicle type and zone in the study area, with the port facility, is given below:

Forecasted Total Daily Commercial Vehicle Trips Generated for Each Vehicle Type and Zone (with Port Facility)

	Zone			
Vehicle Type	**Z_1**	**Z_2**	**Z_3**	**TOTAL**
4-Tire Trucks	24,944	32,421	29,654	87,019
Single Unit (6+ Tire) Trucks	5,692	8,541	7,767	22,000
Combination Vehicles	1,561	2,691	2,866	7,118
All Commercial Vehicles	**32,197**	**43,653**	**40,287**	**116,137**

At external stations, the commercial vehicle trips for each vehicle type with and without the port facility are as shown below:

Commercial Vehicle Trip Origins/Destinations at External Stations

	External Station											
	S1			S2			S3			S4		
Truck AADT: (1-Way)	Before	After	Net	Before	After	Net	Before	After	Net	Before	After	Net
• Four-Tire	2,948	3,048	100	901	1,001	100	650	750	100	2,530	2,630	100
• Single Unit	965	1,025	60	792	852	60	167	227	60	828	888	60
• Combination	2,412	2,452	40	3,331	3,371	40	217	257	40	2,070	2,110	40
Total	6,325	6,525	200	5,023	5,223	200	1,034	1,234	200	5,428	5,628	200

Four-Tire Truck Trip Table

(Vehicles/day)

		Destination Zone (j)								
		Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4	Total (Oi)	Sum(Dj*Fij)
Origin Zone (i)	Z_1	?	?	?	?	?	?	?	24,944	23,295.15
	Z_2	?	?	?	?	?	?	?	32,421	25,402.51
	Z_3	?	?	?	?	?	?	?	29,654	22,752.43
	S_1	?	?	?	0	?	?	?	3,048	708.96
	S_2	?	?	?	?	0	?	?	1,001	813.12
	S_3	?	?	?	?	?	0	?	750	637.66
	S_4	?	?	?	?	?	?	0	2,630	567.63
	Total (Dj)	24,944	32,421	29,654	3,048	1,001	750	2,630	94,448	

Single Unit Truck Trip Table

Using the information above, the following trip tables are estimated for the study area

Combination Truck Trip Table

(Vehicles/Day)

		Destination Zone (j)								
		Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4	Total (Oi)	Sum(Dj*Fij)
Origin Zone (i)	Z_1	?	?	?	?	?	?	?	1,561	3,472.50
	Z_2	?	?	?	?	?	?	?	2,691	3,894.73
	Z_3	?	?	?	?	?	?	?	2,866	3,809.15
	S_1	?	?	?	0	?	?	?	2,452	9.11
	S_2	?	?	?	?	0	?	?	3,371	10.06
	S_3	?	?	?	?	?	0	?	257	9.28
	S_4	?	?	?	?	?	?	0	2,110	8.78
	Total (Dj)	1,561	2,691	2,866	2,452	3,371	257	2,110	15,307	

Following the trip distribution and calibration processes described in Chapter 4, Sections 4.4 and

Single Unit Truck Trip Table

(Vehicles/Day)

		Destination Zone (j)								
		Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4	Total (Oi)	Sum(Dj*Fij)
Origin Zone (i)	Z_1	?	?	?	?	?	?	?	5,692	3,145.26
	Z_2	?	?	?	?	?	?	?	8,541	3,808.02
	Z_3	?	?	?	?	?	?	?	7,767	3,437.00
	S_1	?	?	?	0	?	?	?	1,025	102.94
	S_2	?	?	?	?	0	?	?	852	176.68
	S_3	?	?	?	?	?	0	?	227	136.36
	S_4	?	?	?	?	?	?	0	888	121.11
	Total (Dj)	5,692	8,541	7,767	1,025	852	227	888	24,992	

with the proposed port facility:

lowing the trip distribution and calibration processes described in Chapter 4, Sections 4.4 and 4.5 respectively, the adjusted daily trip tables (in passenger car equivalents or PCE's) for the commercial vehicles are determined as follows:

Daily Trip Table (PCEs)

Four-Tire Truck (PCE = 1)

		Destination Zone (j)							
		Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4	Total
Origin Zone (i)	Z_1	10,186	6,544	3,964	1,272	218	86	244	22,513
	Z_2	6,543	12,885	7,804	958	395	155	520	29,261
	Z_3	3,997	7,872	12,452	425	223	341	1,451	26,762
	S_1	1,273	960	422	0	44	10	42	2,752
	S_2	218	395	221	44	0	6	20	904
	S_3	87	157	342	10	6	0	76	678
	S_4	247	527	1,460	42	21	76	0	2,374
	Total	22,552	29,341	26,666	2,752	907	674	2,352	85,244

Non-Commercial Vehicle Trip Table (PCEs)

		Destination Zone (j)							
		Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4	Total (Oi)
Origin Zone (i)	Z_1	?	?	?	?	?	?	?	49,000
	Z_2	?	?	?	?	?	?	?	62,000
	Z_3	?	?	?	?	?	?	?	54,000
	S_1	?	?	?	0	?	?	?	47,775
	S_2	?	?	?	?	0	?	?	22,677
	S_3	?	?	?	?	?	0	?	9,114
	S_4	?	?	?	?	?	?	0	41,072
	Total (Dj)	49,000	62,000	54,000	47,775	22,677	9,114	41,072	285,638

The non-commercial vehicle trip table is also developed as follows:

Daily Trip Table (PCEs)

Single Unit Truck (PCE = 1.5)

		Destination Zone (j)							
		Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4	Total
Origin Zone (i)	Z_1	4,540	2,121	1,141	398	283	32	97	8,611
	Z_2	2,107	5,960	3,206	749	587	68	245	12,922
	Z_3	1,141	3,225	5,759	272	287	180	885	11,750
	S_1	396	750	271	0	100	6	27	1,551
	S_2	281	588	286	100	0	8	27	1,290
	S_3	32	68	180	6	8	0	50	343
	S_4	97	248	893	29	27	51	0	1,345
	Total	8,594	12,962	11,735	1,554	1,292	345	1,331	37,812

Daily Trip Table (PCEs)

non-commercial vehicle trip table is also developed as follows:

Daily Trip Table (PCEs)

Combination Truck (PCE = 2)

		Destination Zone (j)							
		Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4	Total
Origin Zone (i)	Z_1	640	736	702	1,262	1,390	69	602	5,401
	Z_2	736	1,546	1,431	1,687	2,586	128	1,189	9,304
	Z_3	705	1,435	1,902	1,390	2,330	190	1,954	9,906
	S_1	1,304	1,743	1,431	0	2,666	111	1,227	8,482
	S_2	1,473	2,742	2,462	2,735	0	201	2,047	11,659
	S_3	69	128	190	107	190	0	204	889
	S_4	622	1,231	2,012	1,327	1,999	207	0	7,299
	Total	5,549	9,560	10,131	8,409	11,161	906	7,223	52,940

Daily Trip Table (PCEs)

All Vehicles

		Destination Zone (j)							
		Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4	Total
Origin Zone (i)	Z_1	27,970	17,825	10,330	19,489	5,100	698	4,113	85,524
	Z_2	17,811	37,645	21,707	16,380	9,637	1,319	8,989	113,488
	Z_3	10,367	21,798	33,109	7,151	5,849	2,581	21,363	102,418
	S_1	19,530	16,439	7,188	0	9,623	747	7,032	60,559
	S_2	5,181	9,794	5,977	9,692	0	647	5,239	36,531
	S_3	690	1,321	2,581	744	637	0	5,042	11,024
	S_4	4,137	9,041	21,639	7,034	5,192	5,047	0	52,090
	Total	85,696	113,862	102,532	60,490	36,037	11,039	51,978	461,633

Non-Commercial Vehicle Trip Table

		Destination Zone (j)							
		Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4	Total (Oi)
Origin Zone (i)	Z_1	12,604	8,424	4,524	16,557	3,209	512	3,170	49,000
	Z_2	8,424	17,254	9,266	12,985	6,068	968	7,035	62,000
	Z_3	4,524	9,266	12,996	5,064	3,008	1,869	17,273	54,000
	S_1	16,557	12,985	5,064	0	6,813	621	5,735	47,775
	S_2	3,209	6,068	3,008	6,813	0	433	3,145	22,677
	S_3	512	968	1,869	621	433	0	4,712	9,114
	S_4	3,171	7,035	17,274	5,736	3,145	4,712	0	41,072
	Total Dj	49,000	62,000	54,000	47,775	22,677	9,114	41,071	

The total commercial and non-commercial trips are determined by adding the trip tables above,

Daily Trip Table (PCEs)

<u>Traffic Assignment Segments</u>

All Vehicles

Destination Zone (j)

Origin Zone (i)

	Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4
Z_1	**2,3**	2,3,4,5,6	2,3,4,5,6,8, 9,10	1,2,3	2,3,4,7	2,3,4,5,6,8	2,3,4,5,6,8, 9,10,12
Z_2	2,3,4,5,6	4,5,6	4,5,6,8,9,10	1,2,3,4,5,6	4,5,6,7	4,5,6,8,11	4,5,6,8,9,10,12
Z_3	2,3,4,5,6,8, 9,10	4,5,6,8,9,10	6,8,9,10	1,2,3,4,5,6, 8,9,10	4,5,6,7,8, 9,10	8,9,10,11	8,9,10,12
S_1	1,2,3	1,2,3,4,5,6	1,2,3,4,5,6, 8,9,10	None	1,2,3,4,7	1,2,3,4,5,6, 8,11	1,2,3,4,5,6, 8,9,10,12
S_2	2,3,4,7	4,5,6,7	4,5,6,7,8, 9,10	1,2,3,4,7	None	6,7,11	6,7,10,12
S_3	2,3,4,5,6,8	4,5,6,8,11	8,9,10,11	1,2,3,4,5,6, 8,11	6,7,11	None	10,11,12
S_4	2,3,4,5,6,8, 9,10,12	4,5,6,8,9, 10,12	8,9,10,12	1,2,3,4,5,6, 8,9,10,12	6,7,10,12	10,11,12	None

he total commercial and non-commercial trips are determined by adding the trip tables above, resulting in the following:

The trips above may be assigned to various segments in the study area using distances between origins and destinations. A trip incidence matrix below shows which highway segments can be used for each origin/destination pair (see Figure 5.1):

For example, for the origin-destination pair Z_1 -Z_1, it is assumed that Segment 2 and Segment 3 will each have 60% of the total daily trips (i.e. some of the trips will be using both segments). The assignments for these two segments for all origin-destination pairs are shown in the following tables:

After all the trips have been assigned to all the highway segments, the levels of service of the roads with the proposed facility are compared with their levels of service without the facility as follows:

Link Characteristics and Traffic Conditions with Port Facility

Highway Segment	No. of Lanes	Traffic Volume (pces/day)	Traffic Capacity (pces/day)	V/C Ratio	Change in Volume (pces/day)	V/C Before
1	8	121,049	384,000	0.32	861	0.31
2	6	107,428	288,000	0.37	733	0.37
3	6	121,904	288,000	0.42	484	0.42
4	6	87,435	288,000	0.30	5,495	0.28
5	6	106,619	288,000	0.37	4,474	0.35
6	6	119,275	288,000	0.41	4,751	0.40
7	6	72,568	288,000	0.25	664	0.25
8	4	106,338	192,000	0.55	3,256	0.54
9	6	97,047	288,000	0.34	2,383	0.33
10	6	92,930	288,000	0.32	1,606	0.32
11	4	22,063	192,000	0.11	1,143	0.11
12	8	104,067	384,000	0.27	963	0.27

Segment 2

As can be seen in the table, segments 4, 5, 6, 8 and 9 will experience relatively higher

	Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4	Total
Z_1	**16,782**	8,913	5,165	9,744	1,530	349	2,056	44,539
Z_2	8,905	0	0	8,190	0	0	0	17,095
Z_3	5,184	0	0	3,576	0	0	0	8,759
S_1	9,765	8,219	3,594	0	481	336	4,922	27,318
S_2	1,554	0	0	485	0	0	0	2,039
S_3	350	0	0	335	0	0	0	684
S_4	2,069	0	0	4,924	0	0	0	6,992
Total	44,609	17,132	8,759	27,253	2,011	686	6,978	107,428

Segment 3

	Z_1	Z_2	Z_3	S_1	S_2	S_3	S_4	Total
Z_1	**16,782**	8,913	5,165	9,744	2,805	349	2,056	45,814
Z_2	8,905	0	0	8,190	0	0	0	17,095
Z_3	5,184	0	0	3,576	0	0	0	8,759
S_1	9,765	8,219	3,594	0	9,142	411	2,109	33,241
S_2	2,850	0	0	9,207	0	0	0	12,057
S_3	350	0	0	409	0	0	0	759
S_4	2,069	0	0	2,110	0	0	0	4,179
Total	45,904	17,132	8,759	33,237	11,947	760	4,166	121,904